

# Electric Grid Transactions Modelling with DER-CAM

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**<http://gig.lbl.gov>**

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of New Mexico, Public Service New Mexico, Universidad Pontificia Comillas –  
IIT, Xcogen Energy LLC, CSIRO, NEC

**DER-CAM** DECISION SUPPORT TOOL FOR  
DECENTRALIZED ENERGY SYSTEMS  
ANALYTICS | PLANNING | OPERATIONS



**U.S. DEPARTMENT OF  
ENERGY**

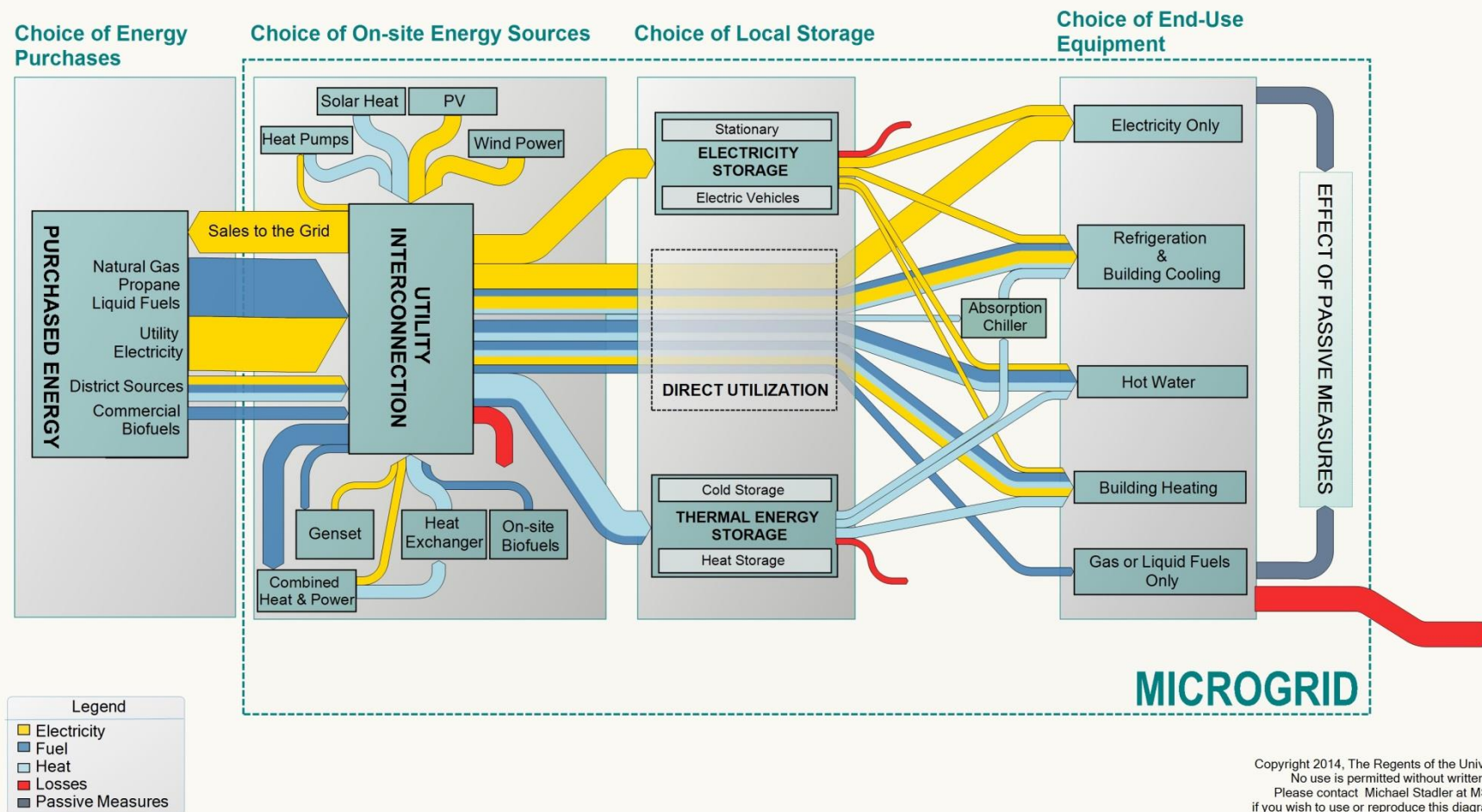


# Global Model for Microgrids and DER in Buildings



U.S. DEPARTMENT OF  
**ENERGY**

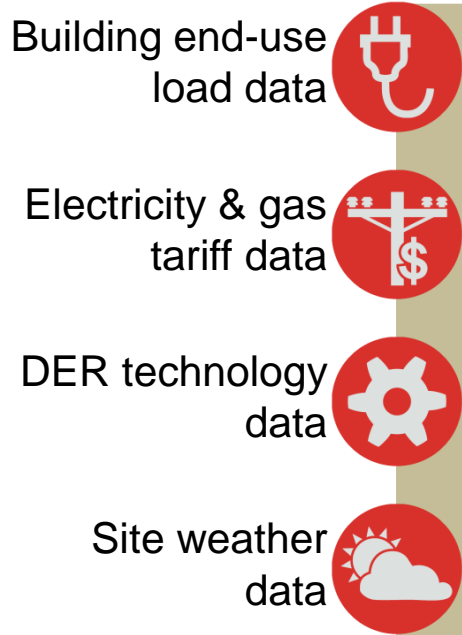
## Microgrid Architecture and Decision Making with DER-CAM



## **Distributed Energy Resources Customer Adoption Model (DER-CAM)**

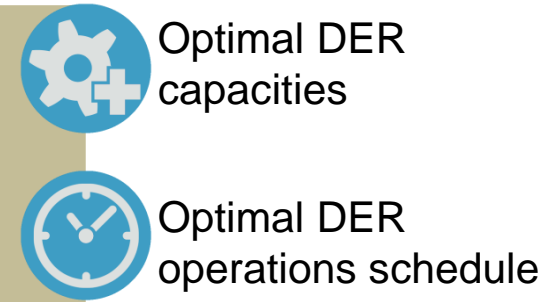
- is a deterministic and stochastic Mixed Integer Linear Program (MILP), written in the General Algebraic Modeling System (GAMS®)
- started as a building CHP optimization tool 13 years ago
- supported by the U.S. DOE, OE, DoD, CEC, private industry
- two main objective functions:
  - cost minimization
  - CO<sub>2</sub> minimization
- other objectives are possible, as well as multi-objective subject to microgrid/building constraints and energy balance
- produces optimal investment and dispatch results for biogas/diesel/natural gas CHP, fuel cells, ICE, micro-turbines, gas-turbines; PV, solar thermal, hot and cold water storage, batteries, heat pumps, absorption chiller, EV, passive measures (insulation, window changes, etc..)

## Inputs:



## DER-CAM

## Outputs:



## Objectives:

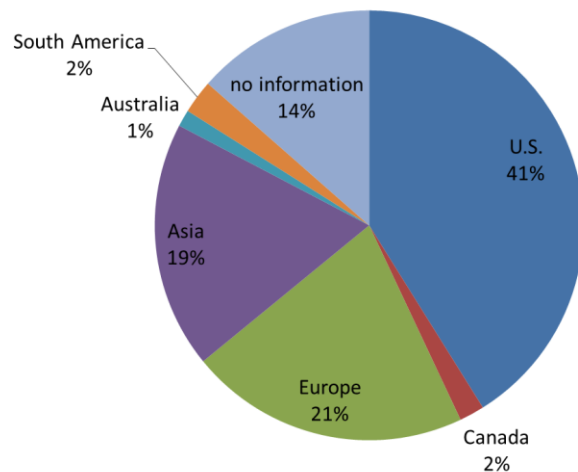


- **Investment & Planning:** determines optimal equipment combination and operation based on *historic* load data, weather, and tariffs → Microgrid Design Tool
- **Operations:** determines optimal week-ahead scheduling for installed equipment and *forecasted* loads, weather and tariffs → Controller

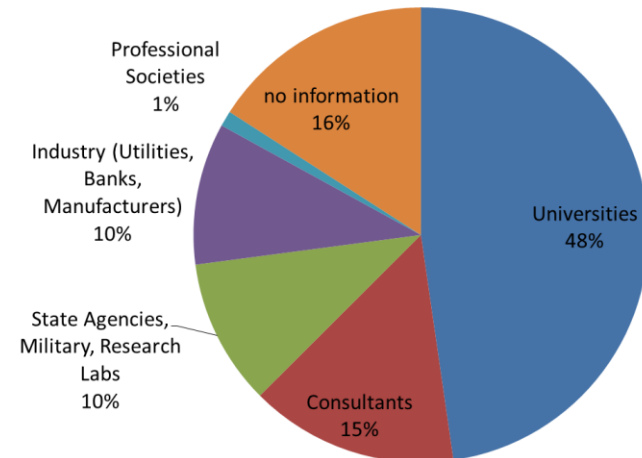
## *DER-CAM Users*

- DER-CAM has been proven by journal papers, reports, and field test (200 hits on Google)
- DER-CAM has been used as microgrid design tool by private entities outside of LBNL
- 700 worldwide users (11% in China, one DER-CAM version has a Chinese interface)

**Web DER-CAM Users (WebOpt) by Region  
(43 Different Countries Total)**



**Web DER-CAM users (WebOpt) by Business Type**





# DER-CAM

DECISION SUPPORT TOOL FOR  
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## Our Partners and DER-CAM Licensees



## Our Partners

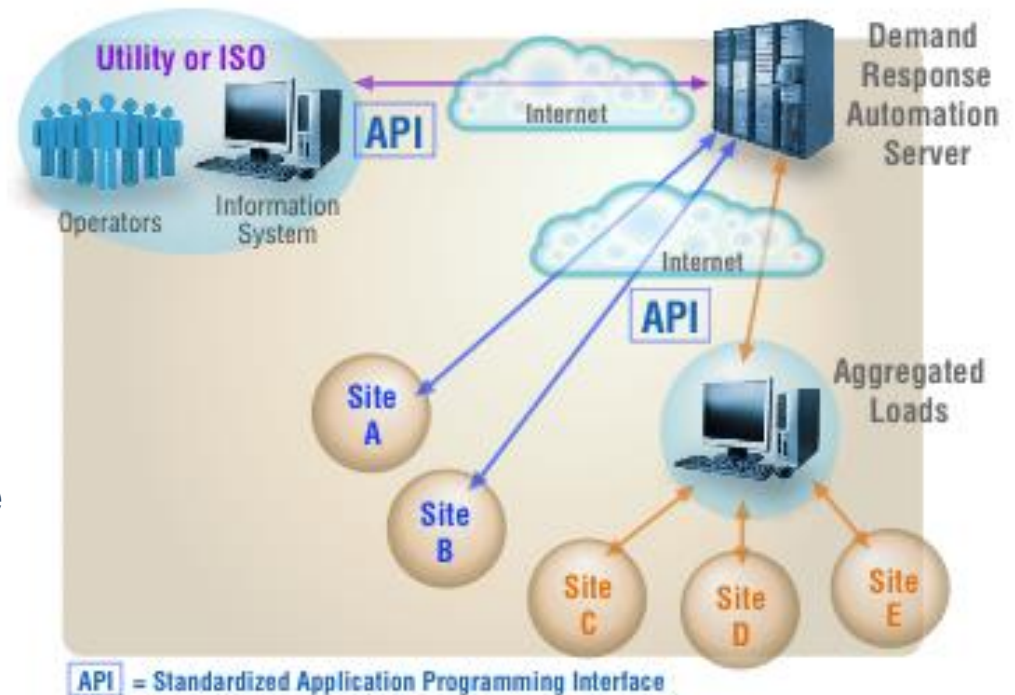


## *Application*

Distributed Energy Systems Integration and  
Demand Optimization for Autonomous  
Operations and Electric Grid Transactions

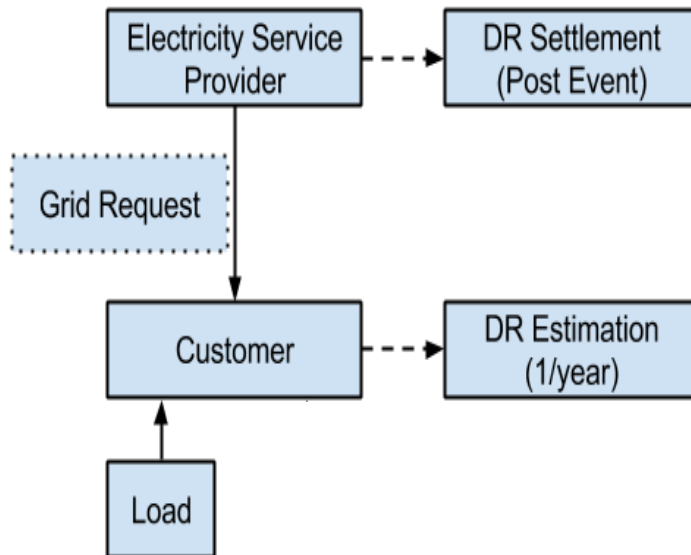
## What is OpenADR?

- OpenADR is standardized communication data model for sending and receiving DR signals from a utility or independent system operator to electric customers
- provides non-proprietary, open standardized DR interface
- allows electricity providers to communicate DR signals to customers
- uses common XML language and existing communications such as Internet

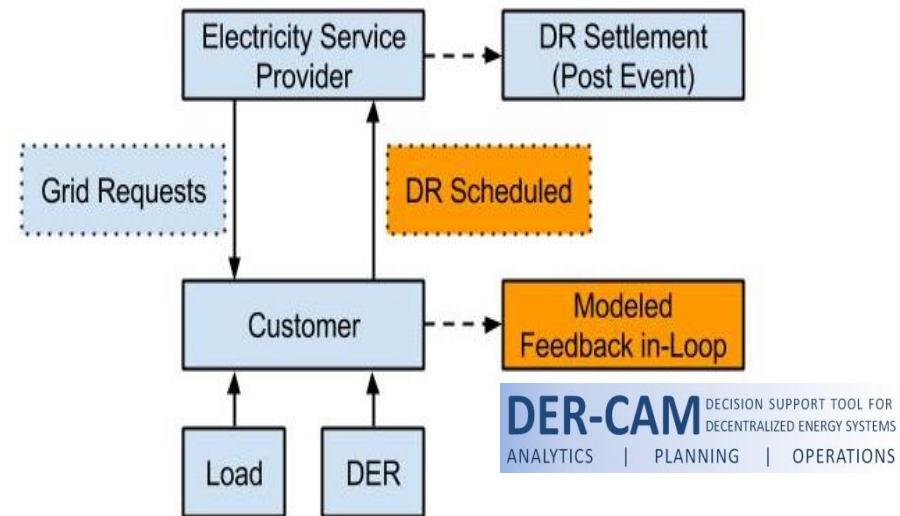




## *Existing Grid Transaction Operation Scenario, and New Dynamic Operation Scheme for Distributed Energy Resources (DER) as Storage, Combined heat and Power, etc.*

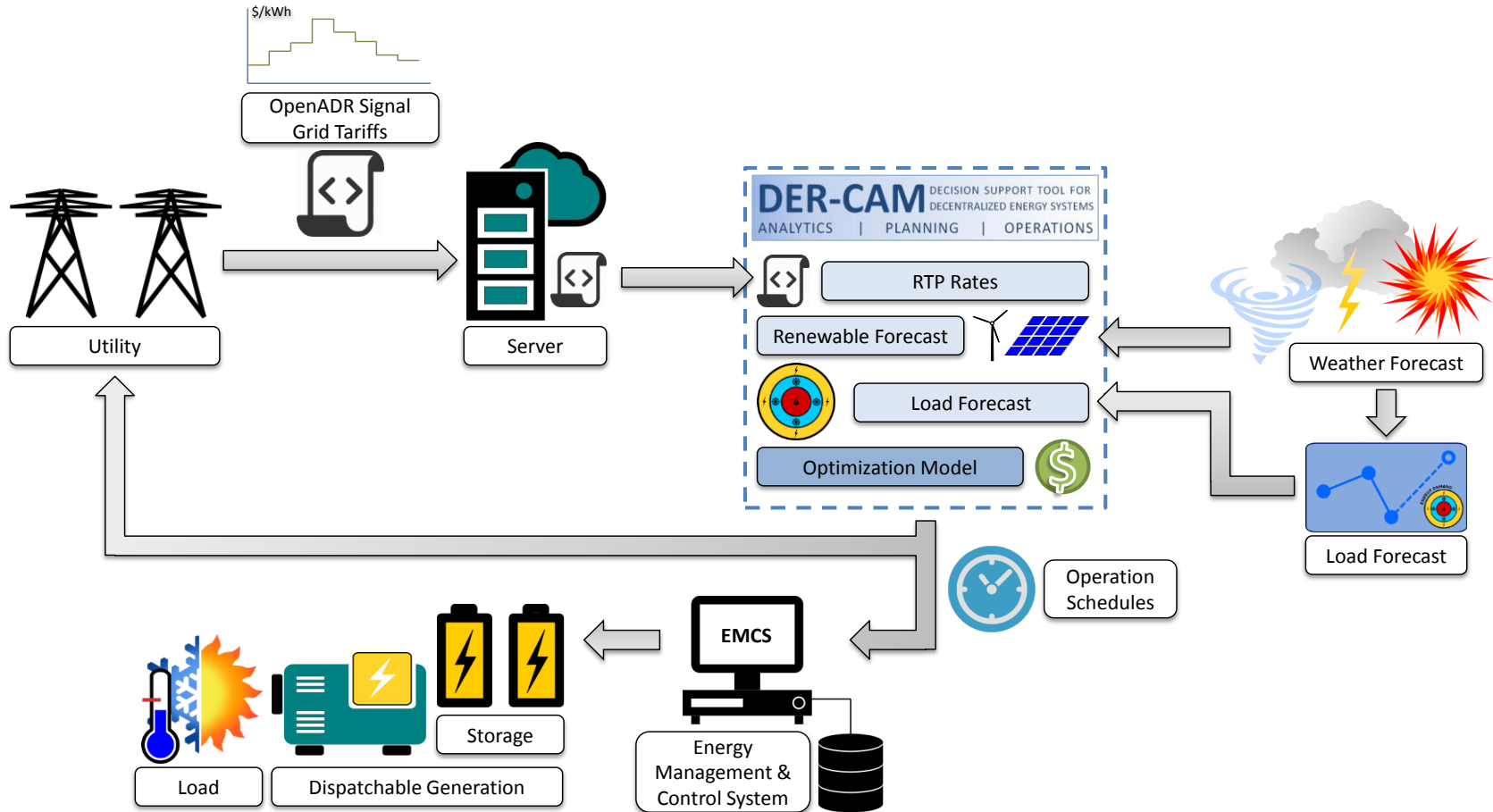


*Old*

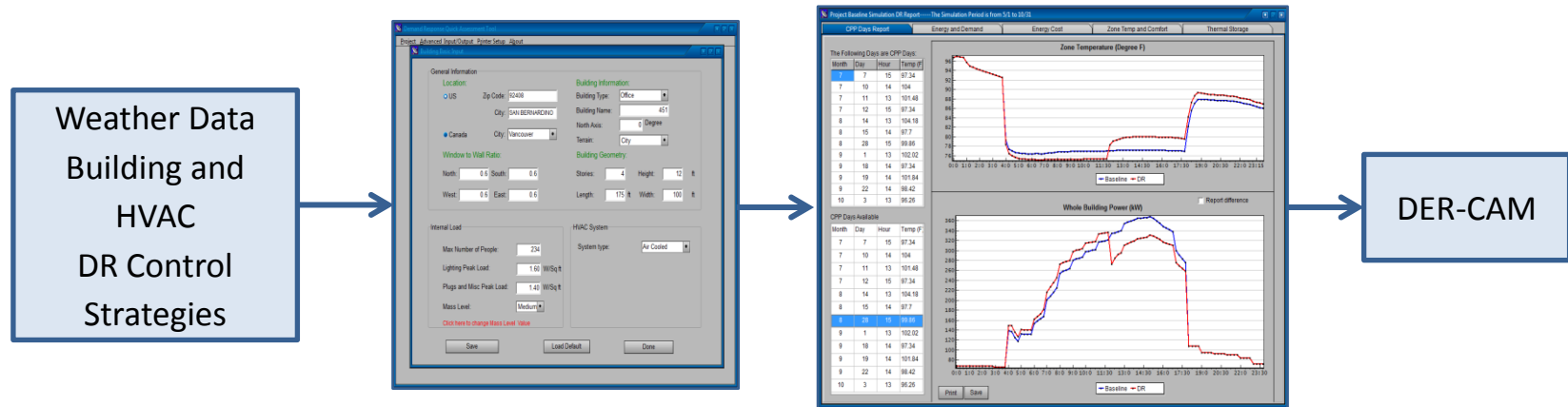


*New*

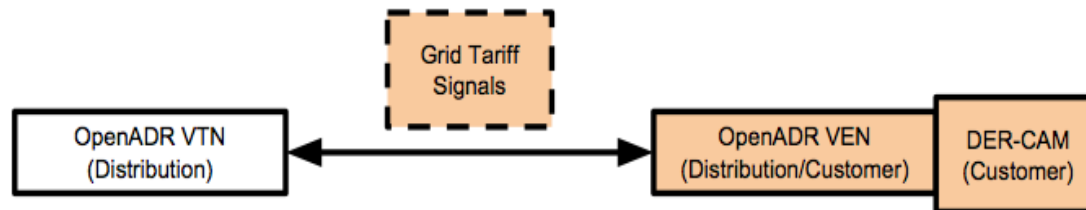
## *Closed-Loop/Model in the Loop Interactions between a DR Service Provider and a DER-CAM-Enabled Customer*



## DR shedding Potential from DRQAT to DER-CAM

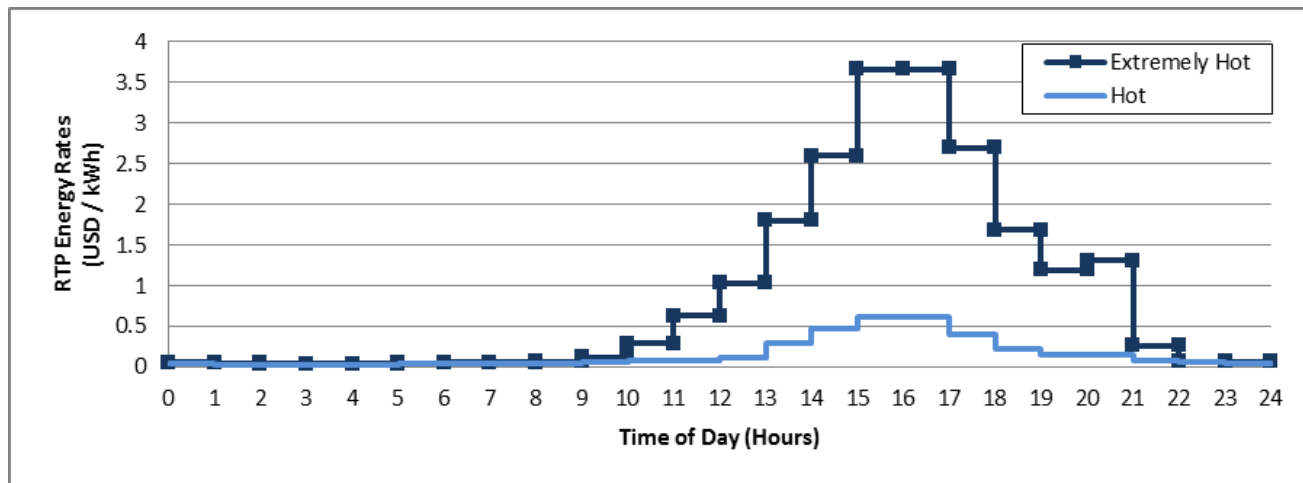


## OpenADR Communication Architecture and DER-CAM Integration



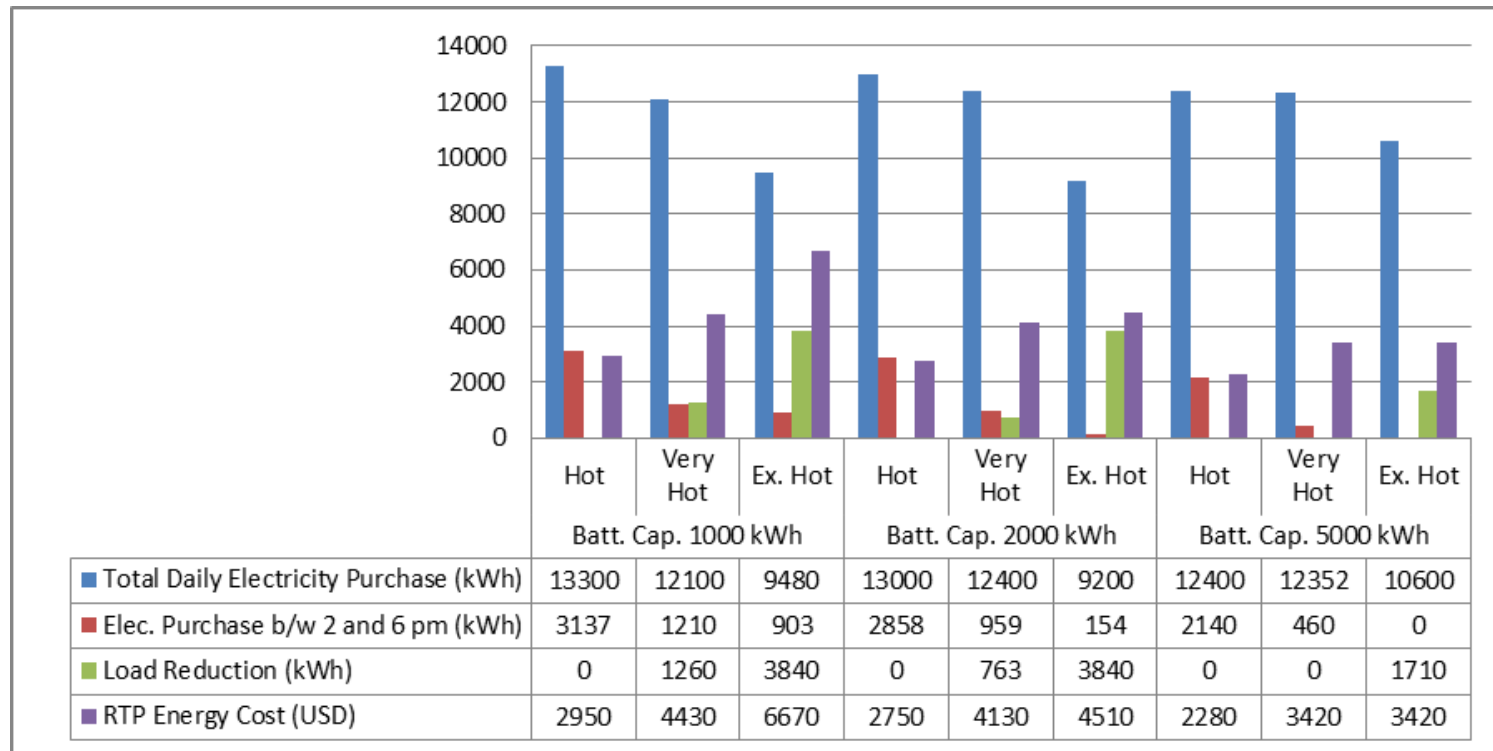
## *Test Case for a Big Campus in California*

- peak electrical load of 2.4 MW
- 2 MW of PV
- 1 MWh of Li-ion battery (2 units of 500 kWh / 625 kW)
- several backup diesel generators, adding up to 4 MW
- Real Time Pricing Program (RTP)
- DR service provider (utility) uploads the RTP hourly prices for the next day to the OpenADR server, RTP prices are determined by supply and demand
- In our case RTP prices depend on temperature (HVAC)



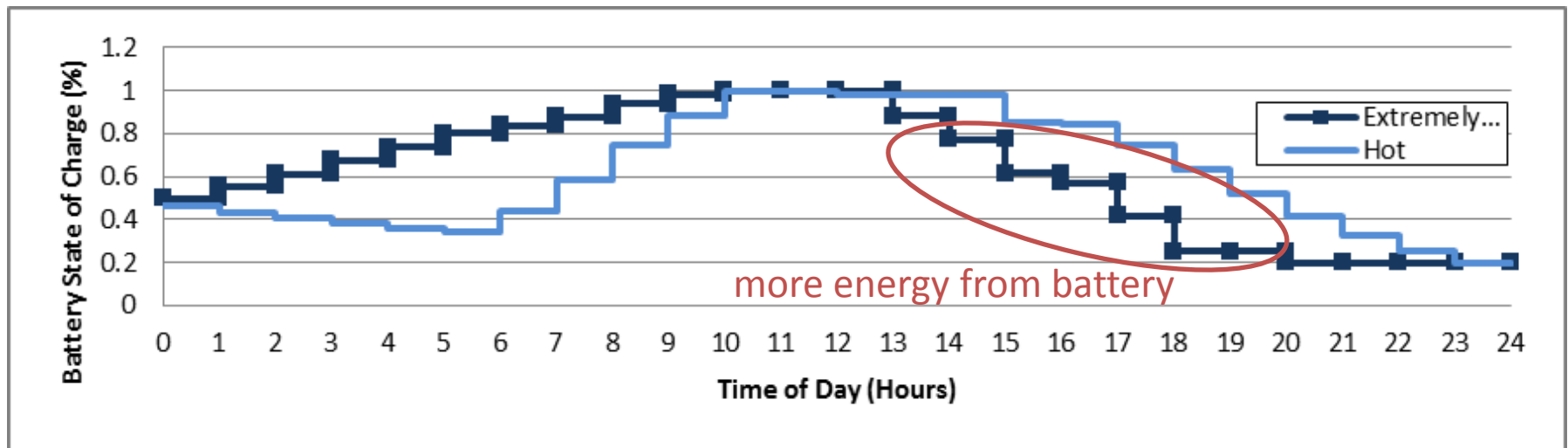
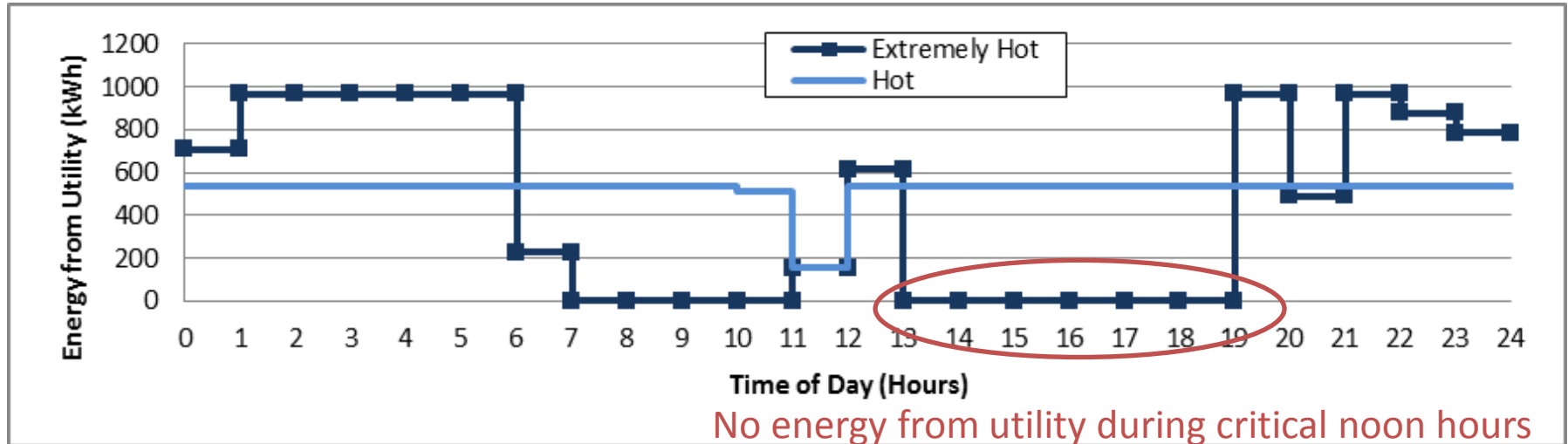
hot: 85°F–90°F  
very hot: 91°F–94°F  
extremely hot:  
≥95°F

## *Results with Daily Energy Cost Limit for Site: 1.5 x Baseline Costs*





## Results with Daily Energy Cost Limit for Site: 1.5 x Baseline Costs, 5MWh Battery



Questions and  
comments are very  
welcome!

THANK  
YOU!

Q&A

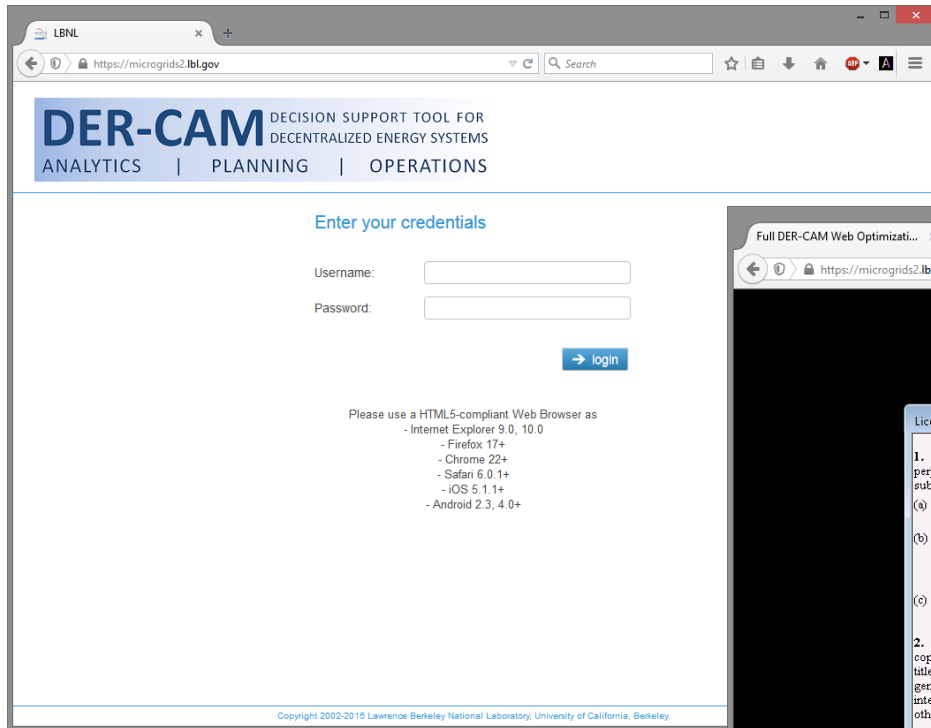
## *Backup Slides*

### Investment and Planning DER-CAM

# DER-CAM

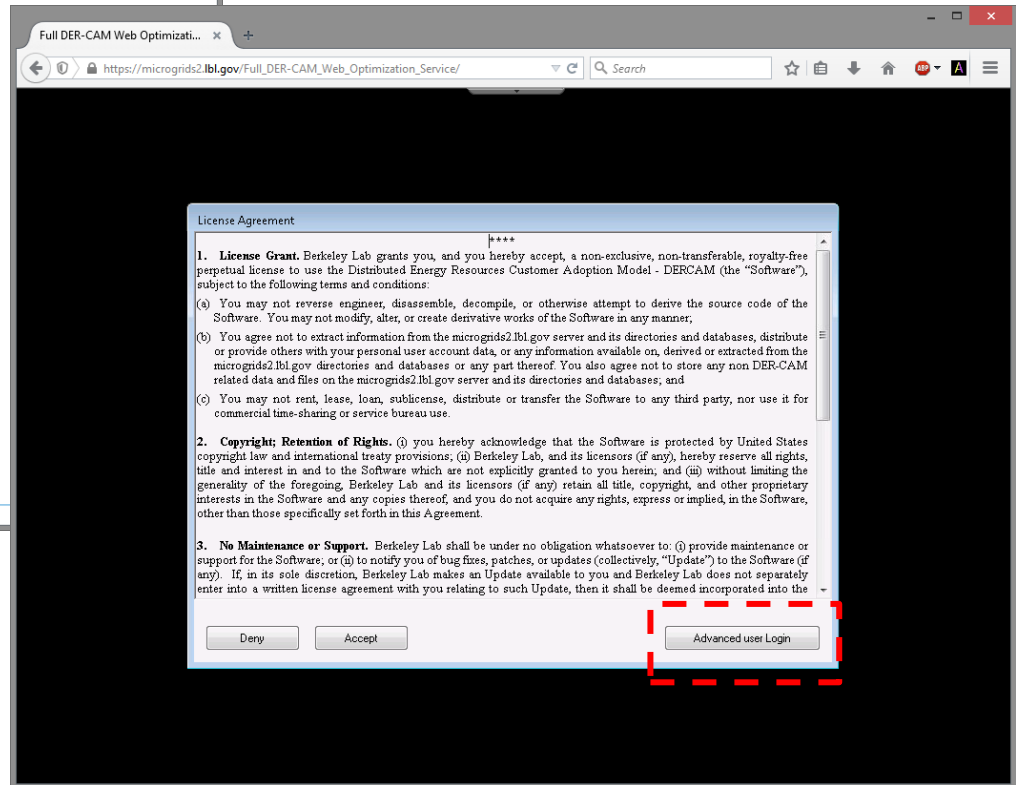
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The screenshot shows the DER-CAM login page in a web browser. The browser's address bar shows the URL <https://microgrids2.lbl.gov>. The page header includes the DER-CAM logo and navigation links for ANALYTICS, PLANNING, and OPERATIONS. Below the header, there is a section titled "Enter your credentials" with input fields for "Username:" and "Password:". A blue "login" button is positioned below the password field. A note below the login fields states: "Please use a HTML5-compliant Web Browser as - Internet Explorer 9.0, 10.0 - Firefox 17+ - Chrome 22+ - Safari 6.0.1+ - iOS 5.1.1+ - Android 2.3, 4.0+". At the bottom of the page, a copyright notice reads: "Copyright 2002-2015 Lawrence Berkeley National Laboratory, University of California, Berkeley."

*Login Screen*



The screenshot shows a "License Agreement" dialog box overlaid on the login screen. The dialog box contains the following text:

**License Agreement**

1. **License Grant.** Berkeley Lab grants you, and you hereby accept, a non-exclusive, non-transferable, royalty-free perpetual license to use the Distributed Energy Resources Customer Adoption Model - DER-CAM (the "Software"), subject to the following terms and conditions:

- (a) You may not reverse engineer, disassemble, decompile, or otherwise attempt to derive the source code of the Software. You may not modify, alter, or create derivative works of the Software in any manner;
- (b) You agree not to extract information from the microgrids2.lbl.gov server and its directories and databases, distribute or provide others with your personal user account data, or any information available on, derived or extracted from the microgrids2.lbl.gov directories and databases or any part thereof. You also agree not to store any non-DER-CAM related data and files on the microgrids2.lbl.gov server and its directories and databases; and
- (c) You may not rent, lease, loan, sublicense, distribute or transfer the Software to any third party, nor use it for commercial time-sharing or service bureau use.

2. **Copyright; Retention of Rights.** (i) you hereby acknowledge that the Software is protected by United States copyright law and international treaty provisions; (ii) Berkeley Lab, and its licensors (if any), hereby reserve all rights, title and interest in and to the Software which are not explicitly granted to you herein; and (iii) without limiting the generality of the foregoing, Berkeley Lab and its licensors (if any) retain all title, copyright, and other proprietary interests in the Software and any copies thereof, and you do not acquire any rights, express or implied, in the Software, other than those specifically set forth in this Agreement.

3. **No Maintenance or Support.** Berkeley Lab shall be under no obligation whatsoever to: (i) provide maintenance or support for the Software, or (ii) to notify you of bug fixes, patches, or updates (collectively, "Updates") to the Software (if any). If, in its sole discretion, Berkeley Lab makes an Update available to you and Berkeley Lab does not separately enter into a written license agreement with you relating to such Update, then it shall be deemed incorporated into the

At the bottom of the dialog box, there are three buttons: "Deny", "Accept", and "Advanced user Login". The "Advanced user Login" button is highlighted with a red dashed border.

Advanced user login allows access to customized versions

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*New Project*

Full DER-CAM Web Optimization Service

FILE VIEW HELP

DER-CAM

Start

New Project...

Open Project...

Announcement

Our server will be maintained for roughly 30 min every Saturday at 10:00 PM California time.

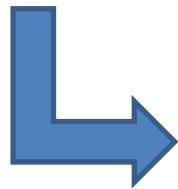
Version History

04.07.2015

Web Interface - v1.4.0.0

- New Features:
  - ✓ Embedded result charts, including investment summary and dispatch profiles.
- Bug Fixes:
  - ✓ Minor display issues.

Ready



Full DER-CAM Web Optimization Service

FILE VIEW HELP

DER-CAM

New Project

Project Name: DemoCase

DER-CAM Version: DER-CAM Version 4.4.1.3

Use DER-CAM Databases: ☒

Load Data

Information on load data

Country: USA

State: CA

City: San Francisco

Building: LargeOffice

Load Profile: New Construction.xlsx

Multiplier: Annual electricity demand X 1.0 GWh

Annual natural gas demand X 1.0 GWh

Solar Data

Information on solar data

TMY: 3

State: California

Solar Profile: SAN FRANCISCO INTL AP.xls

ElectricityOnly Cooling Refrigeration SpaceHeating WaterHeating NaturalGasOnly

250

200

150

100

50

0

0 2 4 6 8 10 12 14 16 18 20 22 24

hours

peak

weekend

week

1

0.8

0.6

0.4

0.2

0

0 2 4 6 8 10 12 14 16 18 20 22 24

hours

OK Cancel

✓ Minor display issues.

Ready

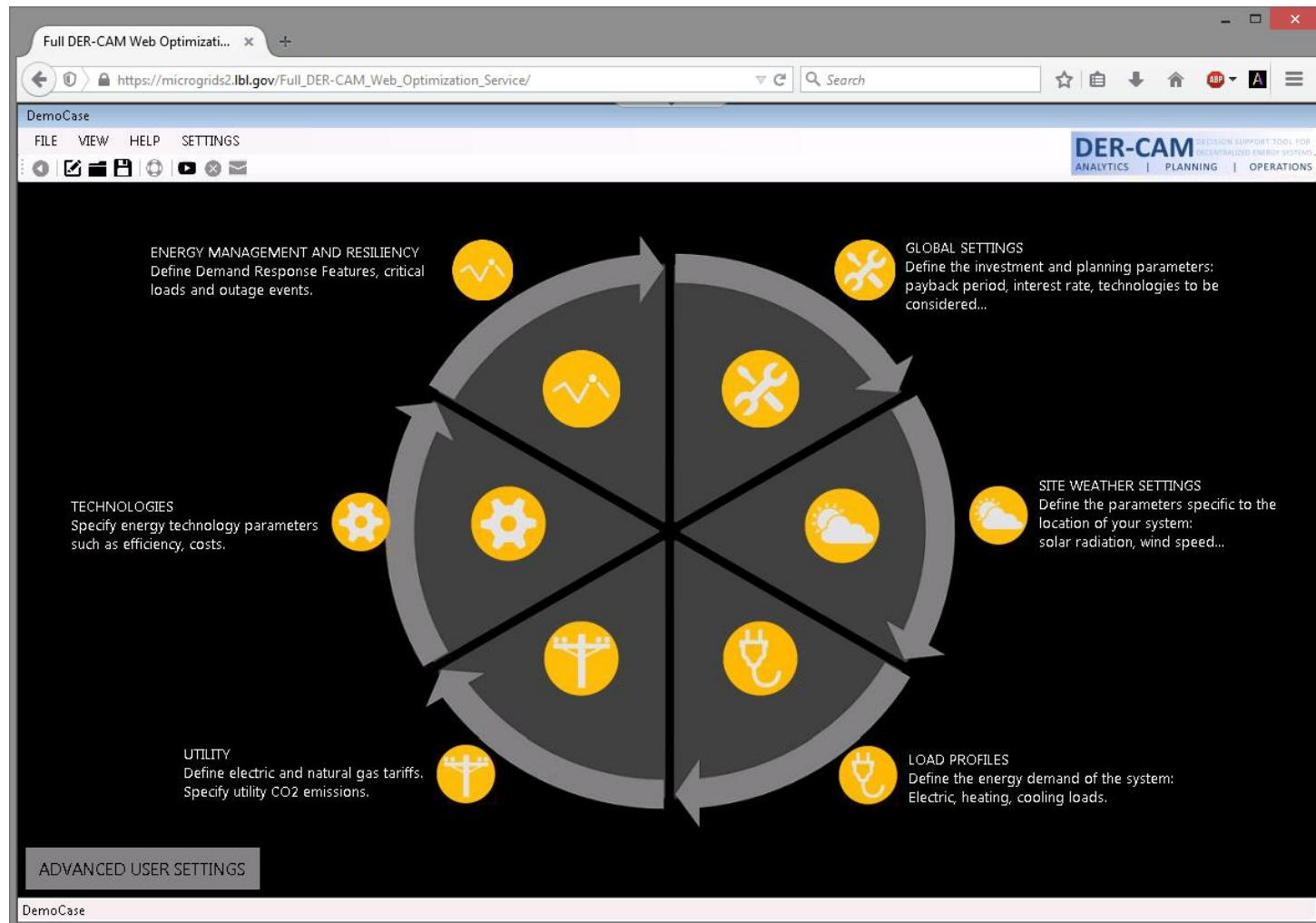


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## Model Overview



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*Model Overview:  
Closer Look at the  
Utility Sub-Menu*

The screenshot displays the DER-CAM web application interface. The browser address bar shows the URL: [https://microgrids2.lbl.gov/Full\\_DER-CAM\\_Web\\_Optimization\\_Service/](https://microgrids2.lbl.gov/Full_DER-CAM_Web_Optimization_Service/). The application has a menu bar with FILE, VIEW, HELP, and SETTINGS. The main content area is divided into a left sidebar (labeled 'Parameters') and a main panel (labeled 'Monthly Demand Rates').

**1: Table navigation** - The left sidebar contains a tree view of parameters. The 'Utility' section is expanded, showing sub-items: Global Settings, Electricity Rates, Power Demand Charges, Fuel Rates, and Fuel Price. The 'Monthly Demand Rates' item is selected.

**2: Data input** - The main panel displays a table with columns: F1, coincident, noncoincident, onpeak, and midpeak. The table lists monthly demand rates for each month of the year.

	F1	coincident	noncoincident	onpeak	midpeak
1	January	0	9.71	0	0.24
2	February	0	9.71	0	0.24
3	March	0	9.71	0	0.24
4	April	0	9.71	0	0.24
5	May	0	16.04	9.71	3.33
6	June	0	16.04	9.71	3.33
7	July	0	16.04	9.71	3.33
8	August	0	16.04	9.71	3.33
9	September	0	16.04	9.71	3.33
10	October	0	16.04	9.71	3.33
11	November	0	9.71	0	0.24
12	December	0	9.71	0	0.24

**3: Help** - A help panel on the right side of the table provides information about the demand rates. It includes a title 'Monthly Demand Rates - Help', a unit '\$/kW', and explanatory text about how demand rates are applied and how power demand charges are calculated.

Ready.

standard window structure: **1**: Table navigation ; **2**: Data input ; **3**: Help

# DER-CAM

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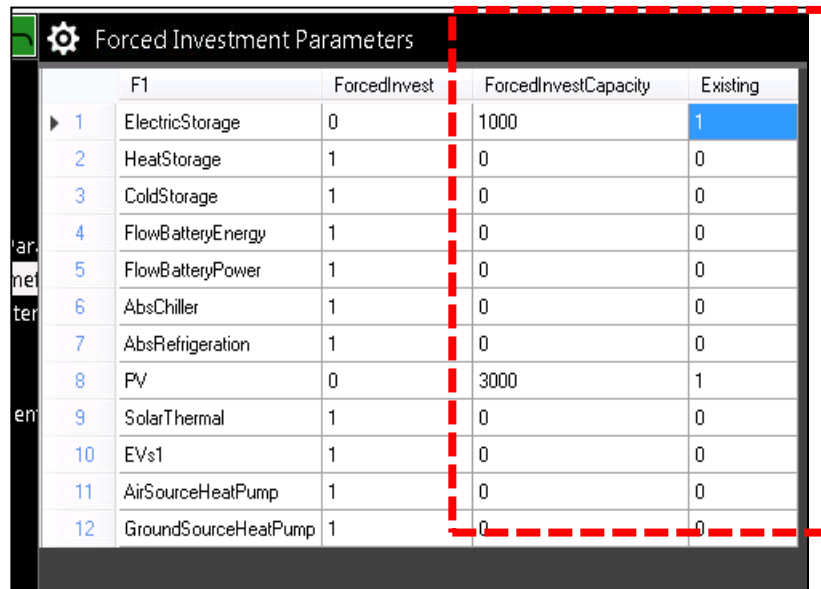
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## *Building a Model: Reference Case vs. Investment Case*

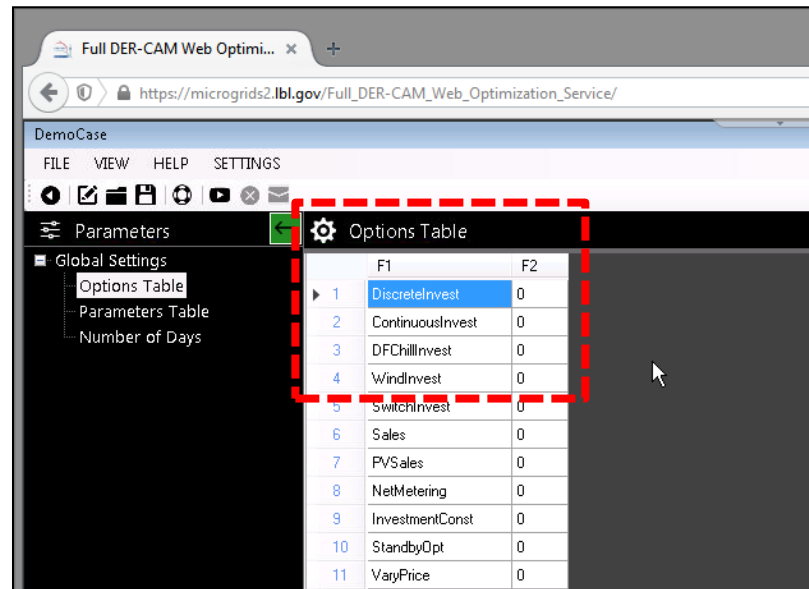
DER-CAM finds the optimal investment solution that satisfies several groups of constrains:

- energy balance (electric, heating, cooling, etc.)
- physical (rated capacity, conversion efficiency, available roof space, etc.)
- economic (discount rate, maximum payback period)

in order to satisfy the economic constrains, a **reference cost** must be obtained and the reference cost can be estimated by running DER-CAM with the existing infrastructure



	F1	ForcedInvest	ForcedInvestCapacity	Existing
1	ElectricStorage	0	1000	1
2	HeatStorage	1	0	0
3	ColdStorage	1	0	0
4	FlowBatteryEnergy	1	0	0
5	FlowBatteryPower	1	0	0
6	AbsChiller	1	0	0
7	AbsRefrigeration	1	0	0
8	PV	0	3000	1
9	SolarThermal	1	0	0
10	EVs1	1	0	0
11	AirSourceHeatPump	1	0	0
12	GroundSourceHeatPump	1	0	0



	F1	F2
1	DiscretInvest	0
2	ContinuousInvest	0
3	DFCchillInvest	0
4	WindInvest	0
5	SwitchInvest	0
6	Sales	0
7	PVSales	0
8	NetMetering	0
9	InvestmentConst	0
10	StandbyOpt	0
11	VaryPrice	0

# DER-CAM

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## *Building a Model: Reference Case vs. Investment Case*

the total annual energy costs obtained in the reference case will then be used in the investment scenarios to allow estimating savings and return period of new investments

The first screenshot shows the 'Parameters' tab with a red dashed box around the 'Launch Run' button. The second screenshot shows the 'Results - DemoCase' page with a red dashed box around the 'Email' icon in the top menu bar. A blue arrow points from the first screenshot to the second.

	F1	F2
106	6.3 Detailed Load	
107		
108	+++++++ Summary ++++++	
109		
110	Total Annual Energy Costs (incl. annualized capital costs and electricity sales)...	234844
111	Total Annual CO2 emissions (kg)	735639

the results obtained in any run are stored on the server and can be sent via e-mail

# DER-CAM

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## *Building a Model: Investment Case*

after updating the reference costs and CO2 emissions, an investment case can be performed

The first screenshot shows the 'Parameters Table' with the following data:

	F1	F2
1	IntRate	0.05
2	Standby	0
3	Controt	0
4	turnvar	0
5	CO2Tax	0
6	macoeff	0.34
7	cooleff	0
8	BaseCaseCost	234850
9	BaseCaseCO2	735639
10	MaxPaybackPeriod	10

The second screenshot shows the 'Options Table' with the following data:

	F1	F2
1	DiscreteInvest	0
2	ContinuousInvest	1
3	DFChillInvest	0
4	WindInvest	0
5	SwitchInvest	0
6	Sales	0
7	PVSales	0
8	NetMetering	0

The third screenshot shows a detailed project configuration table with the following data:

121	+++++++ 1.1.2...				
122					Lifetime
123	Photovoltaic (kW...	186	Size of Photovolt...	1217	30
124	Solar Thermal (kW...	0	Size of Solar The...	0	15
125	Wind power (kW)	0	Installed Capacity...	0	10
126					
127	+++++ 1.2 Ener...				
128					Lifetime
129	Stationary Battery...	98			5
130	Flow Battery Cap...	0			10
131	Flow Battery Pow...	0			10
132	EV Aggregated B...	0	1	Ideal fleet size (c...	0
133	Heat Storage ca...	0			17
134	Cooling Storage ...	0			17
135					
136	+++++ 1.3 HVA...				
137	+++++++ 1.3.2...				
138					Lifetime
139	Air Source Heat ...	0			10

The status bar at the bottom of the third screenshot indicates: "The project has been saved 00:00:48"

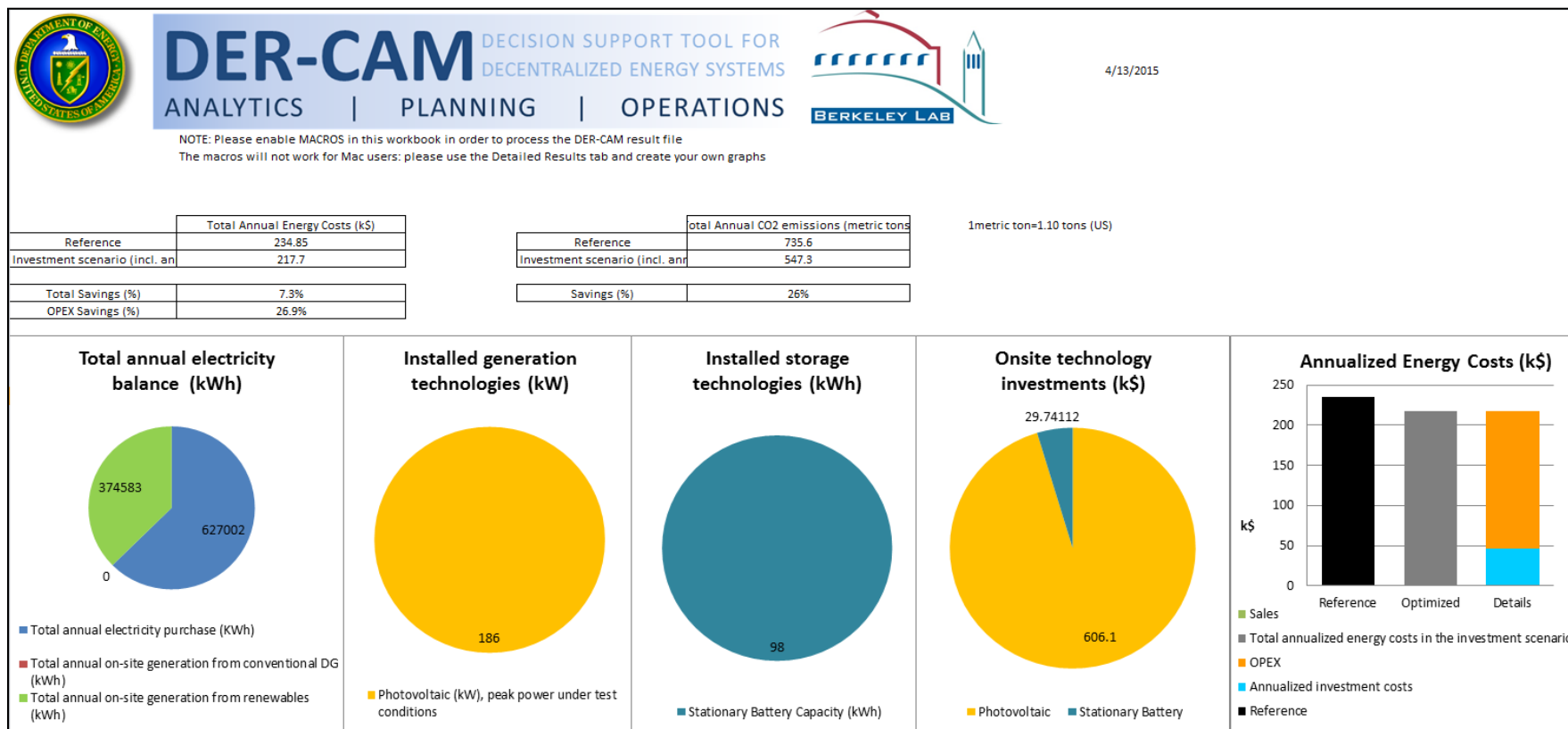


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## Building a Model: Results



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## Building a Model: Results

